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CENTER FOR DISEASE CONTROL  
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH  
CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION DETERMINATION REPORT  
HE 80-44-731

ALASKAN BATTERY ENTERPRISES  
FAIRBANKS, ALASKA

AUGUST 1980

I. SUMMARY

On December 12, 1979 the National Institute for Occupational Safety and Health (NIOSH) received a request from the owner of Alaskan Battery Enterprises to evaluate lead exposure among employees engaged in the manufacture of lead-acid storage batteries (SIC 3691).

An environmental-medical survey was conducted January 8-10, 1980. Personal and area air samples were collected for measurement of airborne lead dust and fume. The medical evaluation included employee interviews and blood tests for lead, free erythrocyte protoporphyrin (FEP), and red blood cell (RBC) parameters.

Breathing zone air lead concentrations ranged from 111 to 1,053  $\mu\text{g}/\text{M}^3$ . All five of eight-hour time-weighted average (TWA) air lead levels exceeded the current OSHA (and State of Alaska) standard of 50  $\mu\text{g}/\text{M}^3$  (respiratory protection is currently permitted between 50-200  $\mu\text{g}/\text{M}^3$ , engineering controls required above 200  $\mu\text{g}/\text{M}^3$ ). General area concentrations ranged from 25 to 129  $\mu\text{g}/\text{M}^3$ . The eight employee blood lead levels determined by the NIOSH contract laboratory ranged from 43 to 87  $\mu\text{g}/\text{dl}$ ; in duplicate blood specimens the NIOSH laboratory measured levels ranging from 38 to 75  $\mu\text{g}/\text{dl}$ . (Blood levels in people not occupationally exposed to lead are usually  $<40$   $\mu\text{g}/\text{dl}$ .) FEP levels ranged from 2,600 to 10,700  $\mu\text{g}/\text{l RBC}$ , all well above the normal range of 220-870. There was no evidence of anemia or symptomatic lead toxicity at the time of the survey.

On the basis of these findings, NIOSH has determined that employees at Alaskan Battery Enterprises, Inc. are exposed to hazardous amounts of lead dust and fume. Recommendations on engineering controls, personal hygiene, respirator usage, and medical monitoring are presented on pages 6-7 of this report.

## II. INTRODUCTION

On November 1, 1979 an employee of Alaskan Battery Enterprises was hospitalized for symptomatic lead poisoning. His physician contacted the company and arranged for blood lead testing of the other employees, two of whom were found to have blood levels exceeding 100 ug/dl. As a result of this the owner of the company began monitoring blood lead levels (approximately monthly) and requested NIOSH to evaluate employees' exposure to lead.\*

An environmental-medical survey was conducted January 8-10, 1980, and environmental results were phoned to the company on February 25, 1980. A written report, including results and recommendations, was submitted to the company on March 13. On March 12, each participant was notified of his or her blood test results, and the owner was notified of the results of the medical study. The latter letter included recommendations on blood lead monitoring.

## III. BACKGROUND

The company assembles, sells, and installs lead-acid storage batteries. Except for several small parts, the components for the batteries are purchased. The assembly process consists of plate stacking, plate burning, boxing, cell connecting, topping, and adding the terminal posts.

Plate stacking involves handling dried plates which are coated with lead oxide. They are removed from wooden pallets, which are used for transporting and storing the plates, and then stacked on top of each other with a separator between them. The positive and negative plates are alternated. This is a dusty operation; each plate is handled individually, and the loose lead oxide dust on the plates can become airborne.

Plate burning consists of connecting the plates together to form a cell. This is accomplished by melting the tabs on the plates with a torch and allowing the melted lead to form the connection. Additional lead is added by melting a lead rod at the point of the connection. Workers are exposed to lead dust generated by handling the dried plates and lead fume from the melting operation.

The boxing operation consists of placing the cell plates in the battery shell. As the plates are inserted in the shell, the air in the shell is forced out past the plates. Since the plates are dry, lead oxide dust

\*Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health and Human Services, following receipt of a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

becomes airborne. After all the cells are in the shell the cells are connected by melting the connecting tabs with a torch. The top is then placed on the battery. Lead dust and fume are generated during this operation.

After the tops are placed, the batteries are put in storage. Just prior to shipping or installation, the terminal posts are added by melting lead from a bar with a torch into a small mold placed over the terminal post opening. This generates lead fume.

There was no local exhaust ventilation or other engineering controls on these operations. The individuals that do the plate stacking and the boxing wore NIOSH-approved respirators for use with lead.

The lead melting pot used for small parts casting has a local exhaust ventilation hood over it.

At the time of the NIOSH survey there were 10 persons working at the shop: the owner; five other full-time employees, two of whom were on vacation out of the state; and four part-time employees. One of the full-time and three of the part-time employees were the owner's children (age range 12-19). The owner and his family, except for the 19-year-old, lived above the plant; the home was entered through a hallway that also opened into both the production and office areas of the plant.

On the advice of the consulting physician, the owner had been removing employees with high blood levels from further lead exposure until the blood lead returned to 40 ug/dl. He had blood lead levels determined in November and December; the January monitoring was scheduled about the time of our survey (see page 6).

#### IV. EVALUATION DESIGN AND METHODS

##### A. Environmental

Breathing zone and area air samples were collected for lead on cellulose ester membrane filters at a flow rate of 1.5 liters per minute. The samples were analyzed for lead according to NIOSH method P&CAM 341 using atomic absorption techniques. The limit of detection was 3 ug of lead per filter.

##### B. Medical

Red blood cell parameters were determined with a Coulter Counter Model S-Plus\* within eight hours after the blood was obtained by venipuncture. Duplicate blood specimens were analyzed for lead (a) by a

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\*Mention of trade names is for information only and does not constitute endorsement by NIOSH.

NIOSH contract laboratory using an atomic absorption procedure,<sup>1,2</sup> and (b) unknown to the contract laboratory, by NIOSH's Clinical and Biochemical Support Section by anodic stripping voltammetry using an ESA Model 3010A\*. Free erythrocyte protoporphyrin (FEP) was determined by the procedure of Chisolm and Brown.<sup>3</sup> (The concentration of protoporphyrin in sonicated whole blood was measured, and the amount per liter of erythrocytes calculated using the previously determined hematocrit.)

In addition to the duplicate blood lead specimens described above, a third specimen from each employee was provided to the laboratory used by the company. The laboratory, which participates in the Center for Disease Control's blood lead proficiency testing program, was unaware that its results would be compared to NIOSH's.

Participants were asked about symptoms of lead toxicity, but because of the small workforce, no attempt was made to administer a formal questionnaire.

#### V. EVALUATION CRITERIA

Lead<sup>4-6</sup> accumulates in the body and is excreted slowly. The general public is exposed to small amounts of lead in food, water, and air. Occupational lead exposure is primarily by inhalation, and to a lesser degree by ingestion (contamination of hands, food, and smoking material). Inorganic lead poisoning is a chronic process, although symptoms may develop suddenly after sufficient chronic exposure. Manifestations of inorganic lead poisoning in adults include decreased appetite, abdominal pain, nausea, constipation (or diarrhea), fatigue, irritability, insomnia, headache, anemia, muscle pain, sore joints, tremor, weakness of the extensor muscles of the wrists and ankles, and impaired kidney function. There is some evidence that occupational lead toxicity can impair fertility.<sup>7</sup>

For lead-acid battery manufacturing, the current OSHA standard (29 CFR 1910.1025) provides for a two-step reduction of the permissible exposure limit for airborne lead from the present 8-hour time-weighted average of 200 ug/M<sup>3</sup> (requiring a respirator if above 50 ug/M<sup>3</sup>) to 50 ug/M<sup>3</sup> by 1984. The standard protects the earnings, seniority, and other benefits of employees who, because of excessive lead absorption, are removed from jobs involving lead exposure.

The blood lead test is one measure of the amount of lead in the body. People who are not exposed to lead at work usually have a blood lead level of less than 40 ug/dl. People exposed to lead at work often have higher levels. Any blood lead level below 80 was formerly considered acceptable for people occupationally exposed to lead, but many

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authorities, including NIOSH, consider lesser blood lead levels to be potentially harmful to health.<sup>4</sup> OSHA regulations will eventually require blood lead levels to average less than 50 (29 CFR 1910.1025). Since blood lead levels even lower than 40 may have harmful effects on the mental development of infants and young children<sup>8</sup>, it is possible that if a pregnant woman has a blood lead level above 30 her unborn child might be adversely affected. For purposes of evaluating the occupational environment, a blood lead level of 50 or more represents excessive lead exposure.

The FEP level measures one of the biologic effects of lead in the body (interference with heme synthesis). With the analytical method used in this study, the FEP level is ordinarily no more than 870 ug/l RBC. The two most common causes of increased FEP are iron deficiency and lead exposure.<sup>9</sup>

Red blood cell count (RBC), hemoglobin (HGB), hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC) measure the number, size, and oxygen-carrying capacity of the red blood cells. Unusually high or low values suggest either a disorder of red blood cell formation or red blood cell destruction. A variety of diseases can cause such effects.

## VI. RESULTS AND DISCUSSION

### A. Environmental

Breathing zone air samples were collected on all four full-time employees present and on one part-time employee for determining their time-weighted average (TWA) exposures. Additional samples were collected to determine the contribution of each job to the TWA exposure and to determine general area levels.

Below is a summary of the air lead results shown in Table 1.

Boxing and topping:	683-1,053 ug/M <sup>3</sup> (8-hour TWA)
Burning plates:	306-401 ug/M <sup>3</sup> (8-hour TWA)
Stacking plates plus other jobs:	340-486 ug/M <sup>3</sup> (8-hour TWA)
Stacking plates only:	833-905 ug/M <sup>3</sup> (2 to 3-hour TWA)
Small parts casting:	111 ug/M <sup>3</sup> (2 to 3-hour TWA)
General area samples:	25-129 ug/M <sup>3</sup> (8-hour TWA)

Respirators were worn by the workers conducting the plate stacking and boxing and topping operations, but there was no effective program of fitting, cleaning, and maintaining the respirators.

All the jobs exceeded the 50 ug/M<sup>3</sup> criterion for airborne lead exposure. Furthermore, the area samples show that the lead is being distributed throughout all the rooms in the building, and in several locations the general area level exceeded 50 ug/M<sup>3</sup>. The plate stacking, plate burning, and boxing and topping operations were the major contributors to these high "background" levels.

B. Medical

All eight employees in town at the time of the survey participated. (This included all family members living above the shop except the owner's wife.) None had other jobs involving lead exposure, and none reported current symptoms of lead toxicity.

Blood lead and FEP levels are shown in Table 2. One person had twin blood specimens sent to both the NIOSH and the NIOSH contract laboratory; this was not known to either laboratory. Within each laboratory, the blood lead results for the twin specimens differed substantially, and the FEP levels were also different. However, the blood lead results of corresponding specimens (i.e., the first of each pair and the second of each pair) were each within 10%, and one of the pairs and the company's laboratory's results were all within 10% of each other. This suggests that (a) this pair represents the correct blood lead level for the person in question, and (b) the cause of the discrepancy may have been an error in specimen identification. This latter possibility could not be confirmed because neither the results of the presumably mis-labeled set of specimens nor those of the presumably correctly labeled set of specimens correspond to the results of any other set of specimens.

In six of nine sets of duplicate specimens, the blood lead results of the NIOSH and NIOSH contract laboratories differed by less than 15%. The differences in the other three sets, which represent the three lowest blood lead levels, are greater. In two cases, corresponding results from all three laboratories were within 10%; in five other cases the difference between the highest and lowest of the three corresponding specimens exceeded 15%. (In one case, the report from the company's laboratory, "< 5," was clearly an analytical or reporting error, and in the remaining case - described above - there was no corresponding specimen sent to the company's laboratory.) In four of the five cases, the results of the company's laboratory were closer to those of NIOSH (all within 15%) than to those of the NIOSH contract laboratory. The laboratories' rank orders of the participants' blood lead levels were similar, with the discrepancies occurring primarily among the lower blood lead levels. In summary, although there were appreciable differences between the three laboratories, it appears that their results are of comparable quality.

FEP levels were all markedly elevated. It is not clear why they were so high, considering their corresponding blood lead levels. One possibility is that the blood lead level is unstable when day-to-day variation in lead exposure is great, and that the high FEP level may therefore be a better indicator of the body burden of lead resulting from intermittent high exposure.<sup>9</sup> On the other hand, the absence of the hypochromic, microcytic anemia characteristic of lead toxicity<sup>10</sup> suggests that some of the higher FEP levels may be inaccurate.

VII. RECOMMENDATIONS

1. Local exhaust ventilation adequate to keep air lead levels below 50 ug/M<sup>3</sup> should be installed in the plate stacking, plate burning, and boxing and topping areas.

2. While engineering controls are being implemented and employee exposure to airborne lead is not yet less than 50 ug/M<sup>3</sup>, appropriate respirators should be used. The respirator program, which includes fitting, cleaning, and training, should comply with the appropriate State of Alaska and OSHA regulations (29 CFR 1910.134).
3. Good housekeeping is very important in reducing the background lead levels. Each area should be vacuumed or washed on a regular basis.
4. No food, drinks, or cigarettes should be stored or consumed in the work area. A separate lunch room should be provided for this purpose.
5. Personal hygiene, such as washing hands before eating, is important in preventing additional exposure to lead.
6. A change room should be provided. Every worker should have two lockers, one for street clothes and one for work clothes. Employees should change clothes at the beginning and end of the shift and shower before going home.
7. The OSHA standards for lead are very specific in such items as respiratory usage, ventilation, work clothing, lunch rooms, change rooms, personal hygiene, housekeeping, environmental and medical monitoring, etc., and should be reviewed. They can be found in Parts 1910.1025 and 1910.34 of the Code of Federal Regulations. These can be obtained from any OSHA area office.
8. Blood lead levels should be monitored at least monthly until lead exposure is reduced to an acceptable level, as evidenced by consistently acceptable blood lead levels. Employees with high blood lead levels (greater than 50 ug/dl) should not be further exposed to lead until their blood lead is below 40.
9. To prevent future contamination of the home, the arrangement and use of the doors to the entrance area should be changed so as to minimize airflow from the shop to the home. The home should then be thoroughly cleaned, and everyone living there should be medically evaluated for excessive lead absorption. Non-employees should enter the home directly from the outside, and employees should shower and change clothing before entering the home.

#### VIII. ACKNOWLEDGEMENTS

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X. DISTRIBUTION AND AVAILABILITY

For the purpose of informing the "affected employees" the employer should post this report for at least 30 days in a prominent place(s) near where employees work.

Copies of this report will be available from NIOSH, Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226 for 90 days. Thereafter, copies will be available from the National Technical Information Service (NTIS), Springfield, Virginia. Information concerning its availability through NTIS can be obtained from the NIOSH Publications Office at the above Cincinnati address.

Copies of this report have been sent to:

Alaskan Battery Enterprises, Inc.  
U.S. Department of Labor, Region X  
Alaska Department of Labor, Division of Occupational Safety and Health  
Alaska Department of Health

TABLE 1  
 AIR LEAD CONCENTRATIONS  
 ALASKAN BATTERY ENTERPRISES  
 FAIRBANKS, ALASKA  
 HE 80-44

<u>JOB OR LOCATION</u>	<u>SAMPLE #</u>	<u>DATE</u>	<u>SAMPLE TIME, MINUTES</u>	<u>SAMPLE VOLUME, LITERS</u>	<u>CONC., ug/M<sup>3</sup></u>
Boxing, topping (plus other jobs, e.g., sales)	25	1/8/80	420	630	683
Burning plates	18	1/8/80	416	624	401
Small parts casting	26	1/8/80	150	225	111
Stacking plates plus other jobs	24	1/8/80	420	630	486
Table in backroom (office)	20	1/8/80	490	735	39
Bench, service and stock area (S.W. corner)	21	1/8/80	483	725	50
Bench in sales area	22	1/8/80	486	729	129
Stock and charging room	23	1/8/80	480	720	59
Stacking plates plus other jobs	29	1/9/80	314	471	340
Stacking plates (only)	30	1/9/80	88	132	985
Topping and boxing (only)	34	1/10/80	355	532	1053
Stacking plates (only)	31	1/10/80	112	168	833
Burning plates (only)	32	1/10/80	120	180	306
General area	33	1/10/80	480	720	26
Display area	35	1/10/80	480	720	61
Front of fan outlet	36	1/10/80	480	720	25
Front of fan outlet	37	1/10/80	480	720	25
<u>Evaluation criterion</u>					50

TABLE 2

BLOOD LEAD AND FREE ERYTHROCYTE PROTOPORPHYRIN (FEP) RESULTS  
ALASKAN BATTERY ENTERPRISES  
FAIRBANKS, ALASKA  
JANUARY 1980

<u>Participant</u>	<u>Blood Lead (ug/dl)</u>			<u>FEP (ug/1 RBC)</u>
	<u>NIOSH Laboratory</u>	<u>NIOSH Contract Laboratory</u>	<u>Laboratory Used by Company</u>	
1*	69	61	48	9,800
	50	52		6,900
2	68	69	73	10,700
3	82	87	75	7,100
4	49	43	54	4,800
5	57	46	60	7,800
6	64	62	5	4,500
7	47	36	45	2,600
8	52	43	38	9,000

\*Duplicate specimens submitted to NIOSH laboratory and NIOSH contract laboratory (see text)